SYSTEMS EVERYWHERE: On the Incorporation of the Vocabulary of Systems Sciences in Architectural Discourse During the Second Half of the 20th Century

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Abstract: Through a consideration of well-known architectural sources, this paper will take inventory of the divergent, contradictory, and sometimes productive ways architects and architectural writers came to rely on the language of systems sciences in the second half of the twentieth century.

For example, in K. Michael Hays' anthology *Architecture Theory Since 1968*, the word "system" appeared 640 times. Alberto Perez-Gomez used the word 51 times in his short introduction to Claude Perrault's Ordonnance to explain methodological changes occurring in seventeenth century France. There are other examples, of course: What Denise Scott Brown and Robert Venturi intended to learn from—far more than Las Vegas or Levittown—were "communication systems;" Jane Jacobs used complexity theory; Christopher Alexander said the city is a system not a tree; and even John Turner, an architect best known for self-build housing in Peru, used Ashby's Law of Requisite Variety (more commonly known as the first law of cybernetics) to argue against corporate and state power.

As Ludwig Von Bertalanffy said in his influential book *General Systems Theory*, "systems [were] everywhere." In this paper, I will untangle this complicated encounter between architecture and information sciences in two ways. First, I will show how systems metaphors have been used as a conceptual tool to define what has been called "architectural autonomy." This includes writers who created a systematic traceable relationship between organizational protocols of architectural form to define architecture as separate from culture, politics, or ideology. Second, I will show examples of how systems have been used as an operative tool for the designer; specifically, architects and city planners who used new sciences of control to solve large complex problems.

Keywords: Systems, autonomy, cybernetics, self-organization

In 1968, while outlining the foundations, applications, and development of a "General Systems Theory," Ludwig Von Bertalanffy observed that everywhere you look people are talking about systems. "If someone were to analyze current notion and fashionable catchwords," Bertalanffy says, "systems" would be high on the list (Bertalanffy 1969). Although successful in displaying the pragmatic potential of Systems Theory as a tool to unite research from diverse disciplines, unforeseen, even in Bertalanffy's introduction titled, "Systems Everywhere," was the important role systems theory would play in fields such as French Structuralism, Functionalist Sociology, Modernization Theory, Geography, Anarchism, and Architecture.[1] Because the expansion of architectural theory in the 1960s and 1970s shared the same conceptual stage as the ascendancy of systems thinking and theory, this final omission of architecture would surprise anyone who has read architectural scholarship in the past half-century, where it seems too, systems are everywhere.

Through a consideration of well-known architectural sources, this paper will take inventory of the divergent, contradictory and sometimes productive ways architects and architectural writers came to rely on the language of systems sciences in the second half of the twentieth century.

For example, when Alberto Perez-Gomez, a historian trained in the 1960s, was reading Claude Perrault, an architect writing in seventeenth century France, what he found were systems (Perez-Gomez 1983).[2] In the most recent translation of Perrault's *Ordonnance for the Five Kinds of Columns After the Method of the Ancients*, a book where Perrault never used the word system (*systematique* or *systeme*), Alberto-Gomez relied on the word fifty-one times in the short introduction to explain the methodological changes he said were occurring in the period (Perez-Gomez 1993). There are other examples, of course: in the same year, what Denise Scott Brown and Robert Venturi intended to learn from—far more than Las Vegas or Levittown—were "communication systems" (Venturi and Brown 1977);[3] in K. Michael Hays' anthology *Architecture Theory Since 1968* the word system appeared roughly the same amount of times (640) as the word building and the word design (Hays 1998); and even John Turner, an architect best known for self-build

housing in Peru, used Ashby's Law of Requisite Variety (more commonly known as the first law of cybernetics) to argue against corporate and state power (Turner 1978).[4]

Each of these examples is part of a significant transformation in the language used to describe the built environment in the 1960s. In some cases, this could be described generally as a move from organic metaphors to systems metaphors. This is apparent in an example like Kenzo Tange's Tokyo Bay Project, which was introduced using biological metaphors such as 'cell' and 'metabolism' in a publication presented at the World Design Conference in Tokyo of 1960 and later in the decade was reconceptualized as a 'structural approach', involving some "Systems Theory" (Colquhoun 2002, 238).[5] In Christopher Alexander's *A City is not a Tree*, this shift is explicitly argued when he says "the system" should replace organic metaphors because of its ability to allow for new forms of mathematical rationality (Alexander 1966).[6]

The examples included above, and many like them, often say more about moods and trends in academic culture than they do about strict methodological change. Take, for example, the use of Complexity Theory by both Robert Venturi and Jane Jacobs.[7] Although these are two very different sources, both use the idea of complexity rhetorically rather than methodologically to address some of the perceived naivetes of what each author called "orthodox modernism"; in the former to understand complex, organized wholes, and in the latter, community self-organization (Venturi 1966; Jacobs 1962).

Of course, not everyone uses the vocabulary of systems or systems metaphors. In some cases, even the language of historians commenting on technological changes in the late 1960s and early 1970s is inconsistent; this includes two historians who never directly address systems theory, Kenneth Frampton and, more surprisingly, Reyner Banham (Banham 1999; Frampton 1985).[8] In a recently published collection of essays spanning the 1960s and 1970s, titled, A C*ritic Writes,* Banham—despite acting as a hype man for the self-regulatory cities and cybernetic meadows of Archigram and conceiving of Los Angeles as a series of interconnected Ecologies—only uses the word system in terms of a collection of related parts such as a "building system" or "glazing system", or in the case of transportation networks such as a system of highways.[9] Frampton never mentions systems in a chapter subtitled, "International Theory and Practice Since 1962" about Cedric Price, Archigram, Buckminster Fuller, Constant, Yona Friedman, and Kenzo Tange—all architects with some relationship to systems science, user-participatory systems, self-organization, and feedback.[10] This is in contrast to the historian Allan Colquhoun, for example, who while writing a survey on the same period—including the same architects—not only discusses systems, cybernetics, and self-regulation but cites Bertalanffy and titles the section of the book, "Systems Theory" (Colquhoun 2002).[11] Even Emil Kaufman, who in 1943 defined modern architecture as "the new architectural system," was relying on the earliest common use of the word system in architecture which was through proportional systems or to define specific codified part-to-whole arrangements (Kaufmann 1943). Modern Architecture, for Kaufman, was a new system precisely because it was no longer a system at all; instead, it was seen as free from previous proportional systems such as the "Baroque System."

By the end of the twentieth century, this appropriation of systems vocabulary is significant enough that it becomes difficult, at times, to connect the things architects say to their original meaning in scientific jargon. In Cary Wolfe's *What is Posthumanism*—a book written 40 years after Bertalanffy's *General System Theory* but taught in many of the same syllabi—an entire chapter is devoted to the systems language used by architects (Wolfe 2010). In a single competition for a park in Toronto in 2000, Wolfe finds the phrases "emergence," "self-organizing," "circuit," "flow ecologies," "sustaining and multiplying complexity over time," "open phasing," "function-based circuit systems," "Webs," and "Grammar strings." "What these terms do," and more specifically what the architects employing these terms do, Wolfe suggests, "is take for granted the conceptual apparatus of systems theory" (Wolfe 2010, 205). In a proposal by the architecture firm, *Corner and Allen,* called *Emergent Ecologies,* the architects say, "our approach is an emergent and dynamic organizational matrix for the life of the site to unfold," in which the "landscape of circuits and flows simply guides or steers the always emergent process of matter and information." Two other proposals analyzed by Wolfe include one by *Brown and Storey* and another by *Foreign Office Architects.* The former is called *Emergent Landscapes* and involves "an evolving landscape of stages, phases of order and stability… evolving relationships, momentum and self-organizing structures," and the latter, a "new synthetic landscape faced with complexity" where the architects "respond by sustaining and multiplying that complexity over time."

Because the language of systems have been incorporated into architecture in such a variety of ways, it would be impossible in a single paper to untangle all of the divergent strands, such as: a way to better understand the interrelationship between actor and observer,[12] the material distinction between inside and outside,[13] the relationship between communication and meaning,[14] and, generally, as a linguistic placeholder

for the common architectural question of order.[15] Instead, in this paper, I will show two ways architects and architectural writers have used systems or the language of systems to define specific goals in their work. First, I will show how systems metaphors have been used as a conceptual tool to define what has been called "architectural autonomy." In this section, I will show examples of architects and architectural critics who have borrowed systems language from sociologists to define the 'formal language' or 'internal protocols' of architecture as a closed system, or more simply, as something separate from culture, politics and ideology. Second, I will show examples of how systems have been used as an operative tool for the designer to accomplish specific goals. On one hand, this type of systems approach gave architects a new vocabulary to critique top down modernist city planning strategies, such as those outlined in the Athens Charter, and on the other, allowed architects and city planners using new sciences of control to solve large complex problems, such as cost efficiency and national development. Using ideas of self-regulation, feedback, user participation, self-organization, steering, and homeostasis many architects expressed the ability of systems sciences, most specifically cybernetics, to design architecture capable of performing clear and understandable objectives; from the organization of cubicles to the settlement of cities in outer space.

1. SYSTEM AS A CONCEPTUAL MODEL TO DEFINE ARCHITECTURAL AUTONOMY

In Cary Wolfe's chapter on architecture in her book, *What is Posthumanism?,* the intent is to expand on what she calls the "central innovation of systems theory," that is, "replacing the familiar ontological dualities of the philosophical tradition with the functional distinction between system and environment" (Wolfe 2010, 206). In this particular chapter, Wolfe uses architectural examples to discuss the ontological duality of nature/culture—something systems theory has been used for by posthumanist thinkers to shift questions of culture away from natural or biological distinctions.[16] This nature/culture question has also been a recent trend in architectural scholarship.[17] However, historically in architectural discourse the use of the functional distinction between system and environment has been used to define architectural form (system) as something separate from categories such as culture, politics, ideology, etc. (environment).

This functional distinction discussed by Wolfe comes from Chilean Biologists Humberto Maturana and Francisco Varela who invented the term 'Autopoiesis' to study the effects of environmental phenomena on organisms (Varela and Maturana 1974).[18] For these two scientists, "autopoietic systems" are biological systems that define and maintain their own material boundaries external to the environment, and although autonomous systems, they are still understood as structurally linked to non-observable environmental effects. This idea, once stripped of its conceptual rigor, or pragmatic purpose for biological study, is intuitively understood by some architects and architectural theorists as a tool to metaphorically define disciplinary boundaries.

The term Autopoiesis found its way into architectural discourse through the writing of Niklas Luhmann (Luhmann 2011).[19] While looking for "a general theory of society," Luhmann published a series of lectures called "Social Systems." Taking from the 1960s functionalist sociologist Talcott Parsons—the first person to define 'the social' as a system of its own—Luhmann incorporated this idea of Autopoiesis and used it to distinguish between 'the social' and other phenomena (biological, phycological, etc.) which are not strictly observable but are still structurally coupled with "the social." Within the Social System, Luhmann defines many other autopoietic subsystems, each containing their own various mechanisms and protocols to define and maintain their boundaries, such as law, economy, politics, art (in this case, including architecture), etc..

In architecture, as shown by Cary Wolfe, the use of this language is sometimes meaningless rhetorical accouterment; however, for some, such as Patrick Schumacher, the term autopoiesis has been central to his attempts to establish a unified theory of architectural autonomy (Schumacher 2011). [20] What is actually meant by Schumacher's use of autopoiesis is not explicit in his work. Instead it appears to be used as a theoretical apparatus to narrow the discussion of architecture to form alone. The specific purpose of ignoring certain external factors, understood as outside of architecture's discipline, is most clear in his recent public comments about eliminating social housing, privatizing all public spaces, developing most of Hyde Park, and perhaps even in his direct affiliation with the death of nearly 1000 migrant workers in preparations for his firm's 2022 World Cup Stadium in Qatar. Instead of drawing on aspects of systems theory to challenge familiar ontological dualities which has been seen in the work of posthumanist theory, Schumacher takes the functional distinction between system and environment literally as a way to promote right wing rhetoric.

What is interesting about Schumacher, for the sake of this discussion, is that his work is drawing on a desire to express the parts of a building as a single self-contained whole. This desire has been expressed using various scientific metaphors throughout architectural history, which he draws upon often conflating and synthesizing distinct architectural arguments. As a

result of this ahistorical approach, there has been significant criticism extended to Schumacher, such as by Antoine Picon, who notes his inability to distinguish this theory from previous models of architectural autonomy such as those presented by K. Michael Hays in the 1980s and 90s (Picon 2011).[21]

This inability of Schumacher to distinguish his own architectural theory from authors like K. Michael Hays and others stems from his reliance on similar intellectual influences. The theoretical legitimacy of architectural autonomy is often derived from structural theorists, whose work is part of a systems approach. This has included "deep structure" from Noam Chomsky, relative autonomy and the ideological state apparatus from Louis Althusser, and the theory of assemblages from Gilles Deleuze and Felix Guattari.[22] Although distinct in their own right, once these conceptual models are brought into the narrow metaphor of architectural autonomy, they are all, in effect, exactly the same.

K. Michael Hays, for example, was relying on the intellectual history of systems theory when he said that architecture should be understood through its internal protocols, that is, "how its parts have been put together, how it is a wholly integrated and equilibrated system that can be understood without external references, and as important, how it may be reused, how its constituent parts and processes may be recombined" (Hays 1984, 16). The use of the idea of a homeostatic "equilibrated system" becomes a tool to discuss these internal concerns as distinct but somehow structurally coupled with economic, political, cultural, and technological processes which are responsible for the various historical transformations in architecture.[23] An example of this type of mediation—and one that Hays cites in his Introduction to *The Oppositions Reader* when trying to work out the relationship between the "historical determinism" of Manfredo Tafuri and the "formal autonomy" of Colin Rowe—is Diana Agrest's 1974 paper "Design vs. Non-Design." In this definition of architectural autonomy, Agrest says:

> Design, considered as both a practice and a product, is in effect a closed system—not only in relation to culture as a whole, but also in relation to other cultural systems such as literature, film, painting, philosophy, physics, geometry, etc. Properly defined, it is reductive, condensing and crystallizing general cultural notions within its own distinct parameters. Within the limits of this system, however, design constitutes a set of practices—architecture, urban design, and industrial design—unified with respect to certain normative theories. That is, it possesses specific characteristics that distinguish it from all other cultural practices and that establish a boundary between what is design and what is not. (Agrest in Hays 1998, 198)[24]

Often when the language of systems is imported into architecture as a tool to discuss, in general, architecture's relationship to culture, it comes with the intent to maintain some formal discourse—something traditionally thought to be unique only to the discipline of architecture and that discipline's primary meta-critical language for resistance against such cultural forces.[25] In other words, if the 'formal language' is not a closed system, architecture's ability to critique culture is suppressed by a belief that culture is embedded within architectural form, and the architect's work is presumed to be nothing but a representation of the culture that produced it. To achieve this mediation between culture and architecture, Agrest is focused on "the discursive specificity of architectural codes which are nevertheless permeable to other cultural codes." This Agrest takes from Louis Althusser's use of a system model to define relative autonomy.[26] In Hays' words, these systems models "show the work of architecture as having some autonomous force with which it could also be seen as negating, distorting, repressing, compensating for, and even producing, as well as reproducing, [its social ground or] context" (Hays 1998, X).

2. SYSTEMS AS A CONCEPTUAL MODEL FOR FLEXIBLE DESIGN

In 1963, Margaret Mead, Marshall McLuhan, Buckminster Fuller, and ten others were invited onto a boat circling the Greek Islands to have a conversation about "the evolution of human settlements."[27] Constantinos Doxiadis, a planner and architect who had designed cities in collaboration with the Ford Foundation and the United States all over the decolonizing world, invited these prominent cyberneticians and information technology theorists to reenact the famous boat ride on the *S.S. Patris* between Marseille and Athens, where the *Athens Charter* was originally signed. On the final day of the trip, in a Greek amphitheater in Delos, the group signed a document called the *Delos Declaration* in an attempt to bring modern city planning into the information age.[28] According to Mark Wigley in his account of this event, *The Delos Declaration* marks a shift in the 1960s to thinking about architectural design through networks rather than objects, or in Wigley's words, "The architect is seen as the networked animal that networks networks" (Wigley 2001, 94).

While the examples in the previous section of "closed systems" and "autopoiesis" were used primarily to analyze architecture, very often, and as this meeting in the Greek Isles attests, systems sciences—in particular, cybernetics—were thought to be the next great tool for architectural design. Often these resulted in a pursuit of more flexibility. Experiments with trying to make cybernetics a viable tool for design took on two distinct but overlapping forms in the 1960s and 1970s. The first was to address how changes in technology could allow the individual more flexible and adaptive

living environments, and the second was to create more economically efficient modes of production. Early examples of these range in scale from Robert Probst's work with The Herman Miller Furniture Company to cities that are designed to cover the globe, such as Constant's *New Babylon.*[29]

In the *Delos Declaration*, and in many examples throughout the 1960s, these attempts at flexibility were often used to challenge the supposed homogenizing effects of modernist top down planning practices, which were said to be unable to foster 'community.' As early as 1953, at the ninth meeting of the *Congrès Internationaux d'Architecture Moderne* (CIAM), Alison and Peter Smithson and Aldo van Eyck used 'systems' to challenge the four categories found in the *Athens Charter*: Dwelling, Work, Recreation, and Transportation. These functionalist categories were replaced by: House, Street, District, and City (Frampton 1985).[30] In these new categories, the house is not understood as a building but a unit of analysis and the street, particularly in the Smithson's Golden Lane scheme, is named the system which maintains and facilitates this base 'family unit.'[31] According to Allan Colquhoun in the 1950s and 1960s, "A 'cybernetic', self-regulating element was introduced into the way cities and large buildings were conceptualized." This is true in the Smithson's work, which Colquhoun says, "Instead of users being presented with predetermined spatial patterns, they were now—at least in theory—offered the means to alter their own micro-environment and decide their own patterns of behavior" (Colquhoun 2002, 234). While this idea is only implied by early examples of Dutch Structuralism and the Metabolists, Colquhoun says, it becomes "the central issue" in the work of Cedric Price, Yona Friedman, Michael Webb, and Constant.[32]

In contrast to architects and designers of the self-regulating megastructures and cybernetic cities, throughout the 1960s there were many efforts to define how new systems approaches could be used to make the production of architecture cheaper and more efficient. In 1967, the magazine *Progressive Architecture* devoted an entire issue, titled "Performance Design," to the organization of office space and the "science" of design. In a direct response to this issue but also to consolidate many of the ideas emerging in systems thinking in the 1960s, James Boyce wrote an essay called "What is the systems approach?" (Boyce, 2007).[33] Here he defined explicitly three ways systems sciences could be used by architects: sequential design processes, cyclic-design processes, and evolutionary design processes. A year later, Benjamin Handler wrote a book called *Systems Approach to Architecture* where he was attempting to solve, once and for all, the complexity of decision making in architectural projects by outlining every measurable part of a building's life; from "auditory comfort" and "illumination levels" to "blood pressure" and "discrimination" (Handler 1970). In far greater schematic detail than Boyce, Handler systematically breaks the design process and "life of the building" into manageable architectural subsystems with understandable inputs and calculatable outputs, based on performance objectives in the design program.

In 1973, The United Nations Department of Economic and Social Affairs looked to implement many of these findings in a book called *Integration of Housing into National Development Plans: A Systems Approach.* Building on the ideas published by Handler, the authors of the report outlined "an econometric simulation model primarily oriented to the situation of the developing countries." This model simulates the impact on the economy, family income, the rate of rural-urban migration, the level of infant mortality, overcrowding, educational levels, and in particular, the demographic and social aspects of housing.

For the Smithson's and those using cybernetics mentioned by Colquhoun, individualized, flexible housing was thought the challenge to the supposed homogenizing modernist housing blocks. For the United Nations and transnational credit institutions, such as World Bank, individual housing was also a way to challenge large-scale modernist slab housing, which was seen as a poor investment for national economies and transnational credit intuitions because of the high capital-output ratio associated with construction. This is evident throughout the 1970s when several conferences and world congresses, such as the *World Congress of Architecture and National Development* held in Mexico City in 1978, looked to combine these new computationally driven economic housing strategies with architects' technological ambitions.

By the late 1970s, the word system was so malleable that it could serve as both a conceptual alternative to functionalist top-down modern city planning strategies and advance new economic models of 'development'. This malleability can be seen at the event in Mexico City, where, on one hand, architects from most Latin American countries accessed flows of international finance and took part in conversations with politicians, economists, and technocratic elites, and on the other, architects such as those associated with the Lima-based intellectual movement, *Agrupacion Espacio,* presented their critique of the *Athens Charter* named *La Carta de Machu Picchu* (Kahatt 2011).[34] Like *the Delos Declaration*, *La Carta de Machu Picchu* used the language of systems and self-organization, however, this was intended to comment on the inability of the *Athens Charter* to accommodate local specificity.

Given the divergent, ambiguous, and contradictory ways systems thinking has been incorporated into architecture, one question emerges: Why do architects and architectural writers so consistently rely on the vocabulary of systems and systems metaphors? According to Benjamin Handler, "The systems concept is implicit in the way in which architects think and work." He continues by saying, "a building is a system" that is "an interconnected complex of functionally related components designed to accomplish a particular objective" where "the whole is primary, the parts secondary" (Handler 1970, 21). It is probably true that the understanding of architecture described by Handler has allowed some architectural thinkers to easily conflate a historical language of part-to-whole with the analytical tool, 'systems'. While this seems reductive, perhaps this is exactly why Alberto Perez-Gomez sees systems when Perrault questions Vitruvius and Schumacher sees systems when Alberti cites Cicero. Adrian Forty, in his book *Words and Buildings,* says the word "circulation" as an architectural metaphor taken from science, first by Charles Garnier and Viollet-le-Duc, may be related to this desire to express the parts of a building as a single self-contained whole (Forty 2000). Whether these types of linguistic conflation are occurring in the examples referred to in the paper is impossible to say. However, like other scientific metaphors, this reliance on the vocabulary of systems is often made as a claim of scientific legitimacy. Both cases brought up in the second half of this paper emerged in the postwar period when critiques of architectural modernism's supposed failure to fulfill its social promises shared the same conceptual stage as the advent of systems theory.

ENDNOTES

1 Bertalanffy notes the use of systems theory in Piaget and Levi-Strauss' in the updated 1973 preface. In sociology the two main sources in the 1960s are Talcott Parsons, *The Social System,* (Glencoe: Free Press, 1951) and Robert K. Merton, *Social Theory and Social Structure,* (Glencoe: Free Press, 1949). In the 1980s these are expanded upon by Niklas Luhmann, *Introduction to Systems Theory*, trans. Peter Gilgen, (Cambridge, UK ; Malden, MA: Polity, 2012). On the first page of Fernando Henrique Cardoso and Enzo Faletto's book, *Dependency and Underdevelopment in Latin America,* the authors note that in modernization theory, Talcott Parsons and Robert K. Merton "Have decisively influenced the formulation of the type of development analysis that "argued that Latin American societies belong to structural type generally called 'traditional,' which is giving way to another type of society called 'modern.' Another, very different example of using a system model to challenge modernization theory is Immanuel Wallerstein, *The Modern World-System: Capitalist Agriculture and the Origins of the European World Economy in the Sixteenth Century*, (London: Academic Press, 1974). For the ways the language of 1960s anarchism was effect by the incorporation of cybernetics see: John Duda, "Cybernetics, Anarchism and Self-Organisation," *Anarchist Studies 21.1* (London: Lawrence and Wishart, 2013). 52-72. John McEwan, 'Anarchism and the Cybernetics of Self-Organizing Systems'. *Anarchy* 31: (1963). 270-83. And Colin Ward, 'Anarchism as a Theory of Organisation'. *Anarchy*, 62: (1966) 97–109.

2 Alberto Perez-Gomez, *Architecture and the Crisis of Modern Science* (Cambridge: MIT Press, 1983). We are lead to believe authors of 17th century France were not using the word system (except for perhaps in one account where Alberto-Gomez says Blondel was reading Galileo), however, that all along architects were talking about systems and, because of this, something inherent to the methodology of practicing architects was changing, following Perez-Gomez: "Theory thus reduced to a self-referential system whose elements must be combined through mathematical logic must pretend that its values, and therefore its meaning, are derived from the system itself."

3 Robert Venturi, Denise Scott Brown, and Steven Izenour, *Learning from Las Vegas* (Cambridge: The MIT Press, 1977). This is made clear on the translucent dust jacket that came with the first edition, which gives alternative titles for the book to read: "Symbol in Space before Form in Space: Las Vegas as a communication system." And "System and Order on the Strip"

4 John Turner, "Housing in Three Dimensions: Terms of Reference for the Housing Question Revisited," *World Development Vol 6 No. 9/10.* (1978): 1134-1145. See W. R. Ashby, "Self-regulation and requisite variety', Chapter 11 of *Introduction to Cybernetics,* (New York: Whiley, 1956), reprinted in F. E. Emery (ed.), *Systems Thinking* (Harmondsworth: Penguin, 1969). "If stability (of a system) is to be attained, the variety of the controlling system must be at least as great as the variety of the system to be controlled." This, Turner used to argue that any society complex enough to support corporate organization would have a housing system far too complex to be managed by that corporate organization. p. 1141.

5 David B. Stewart, *The Making of a Modern Japanese Architecture, 1868 to the Present* (Tokyo and New York, 1987), 179-181. Quotation found in Alan Colquhoun, *Modern Architecture* (Oxford: Oxford UP, 2002), 238.

6 Christopher Alexander, "A City Is Not a Tree," *Design* (February 1966), 48; originally published in slightly different form in: Architectural Forum (April 1965), 58-62 and (May 1965): 58-61. See also: Andrew Shanken, "The Tree in the System: Shifting urban paradigms in Mid-Century London," *Perspecta, Vol. 45, Agency* (2012), 143-152.

7 Robert Venturi, *Complexity and Contradiction in Architecture* (NY: MOMA Press, 1966) and Jane Jacobs, The Death and Life of Great American Cities (NY: Vintage, 1992). One essay connects these two writers through the use of Complexity theory, see: Peter Laurence, "Contradictions and Complexities: Jane Jacob's and Robert Venturi's Complexity Theories" *Journal of Architectural Education, Vol. 59, No. 3,* (Feb., 2006), 49-60.

8 Reyner Banham, *Theory and Design in the First Machine Age* (Cambridge: The MIT Press, 1980) Reyner Banham, *A Critic Writes: Selected Essays by Reyner Banham* (California: U California Press, 1999) Reyner Banham, *Architecture of the Well-Tempered Environment* (Chicago: U Chicago P, 1984) Reyner Banham, *Megastructures: Urban Futures of the Recent Past* (London: Thames and Hudson, 1976). Kenneth Frampton, *Modern Architecture: a Critical History* (London: Thames and Hudson, 1985)

9 System of Highways comes from 1950s systems sciences as part of a decentralization brought on by the "Urban Dispersal movement." According to Reinhold Martin, "the organizational complex itself as seen through the medium of an emergent cybernetics and, in particular, through the application of redundant feedback loops to an urban context in which the city was understand as a primary cold war target. In this cybernetic sense, decentralization, or the dispersal of urban infrastructures into an increasingly horizontal network of communicaion and transportation lines, was an instrument not merely of civil defense against an external enemy, but of defense against an internal one: the disorder that was anticipated with the demise of centralized governmental and civil authority in the immediate aftermath of a nuclear strike. And so technocratic aesthetic research accelerated in the direction of ever more efficient mechanisms of self-regulation, self-organization. These in turn helped invent new kinds of cities, new kinds of architectures, and with them new "self," none of which could be said to possess the traditional spatial properties that divide inside from outside in any meaningful sense." For a more detailed discussion of "urban dispersal movement" and its relationship to post war architecture and city planning, See: Reinhold Martin. *Organizational Complex*. (Cambridge: MIT Press, 2005), 7. See also: National Interstate and Defense Highways Act of 1956." June 29, 1956; Enrolled Acts and Resolutions of Congress, 1789-1996; General Records of the United States Government; Record Group 11; National Archives.

10 Kenneth Frampton, *Modern Architecture: a Critical History* (London: Thames and Hudson, 1985), 280-313.

11 See: Alan Colquhoun, *Modern Architecture* (Oxford: Oxford UP, 2002). 235. See also: Hans Ulrich Obrist, *Yona Friedman: The Conversation Series* (Köln: Verlag der Buchhandlung Walther König, 2007).

12 See: Lily Woodruff. "The Groupe de Recherche d'Art Visuel against the Technocrats" Art Journal, Vol. 73, No. 3 (Fall 2014), pp. 18-37. Monica Amor, "From work to Frame, In between and Beyond: Lygia Clark and Helio Oiticia, 1959-1965," Grey Room 38 (winter 2010); 20-37. See also Joan Littlewood's reading of Brechtian Theatre in Theatre Workshop manifesto (c. 1930s) Joan Littlewood Archive, British Library. For accounts of epic theatre and Brecht more generally, see Sarah Bryant-Bertail, *Space and Time in Epic Theatre* (Rochester, NY: Camden House, 2000); Manfred Wekwerth, *Daring to Play: A Brecht Companion*(London: Routledge, 2011); and David Barnett: *Brecht in Practice: Theatre, Theory and Performance*(London: Methuen, 2015).

13 Lloyd Thomas, Katie, "Between the womb and the world: Building Matrixial relation in the NICU" from Peg Rawes, *Relational Architectural Ecologies: Architecture, Nature and subjectivity,* (New York: Routledge, 2013) 192-208. For a conflation of systems theory and emergence of inside/outside questions associated with architecture. At a larger scale see: William J. Mitchell, *Me++: The Cyborg Self and the Networked City* (Cambridge: The MIT Press, 2004), at the scale of building design, Greg Lynn, ed., *Folding in Architecture* (New York: John Wiley & Son, 2004); for a collection of writing associated with this trend See: Mario Carpo, ed., *AD Reader: The Digital Turn in Architecture 1992-2010* (Chichester: Wiley, 2012).

14 See: Peggy Deamer. "Structuring Surfaces: The Legacy of the Whites." *Perspecta, Vol. 32, Resurfacing Modernism* (2001). Because cybernetics is a science of communication, the relationship between meaning and communication has been a central feature in much of the work that looks at cybernetics, however, one way this has been transformed into an architectural theory is through the work of Peter Eisenman. It could be argued that his interpretation of Chomsky's concepts "deep structure" and "surface structure" in the 1960s was not to understand the social construction of language nor its mere phonetic form (surface structure), but instead to understand the specifics underlying the human being's universal ability to understand the relative organization and nonfigurative order of language. This idea helps Eisenman define his version of "architectural autonomy"," primarily because language is an imperceptible vehicle and further, its "deep structure" has no representational form. Or, as Peggy Deamer has described it: "language's seeming universality as a logic made it a meta-system, not an outside discipline." For a clear description of Eisenman's use of "deep structure." p. 94.

15 See Adrian Forty. "Order" in *Words and Buildings: A Vocabulary of Modern Architecture*. (London: Thames and Hudson, 2000). 240-249. This shift away from order has often been attributed rather reductively to architects' reading Foucault and Lefebvre, which according to the historian Adrian Forty made "it no longer possible to talk about 'order' innocently in architecture." Forty names the final paragraph of Foucault's "the Order of things" as an important genealogical strand for this type of thinking, and uses Bernard Tschumi as a positive example of attempting to side step the traditional ways modern architecture has entangled with capitalism and modern science. This discourse surrounding contemporary questions of order is so entrenched in systems language that by the 21st century even Adrian Forty—whose book *Words and Buildings* pays particularly close attention to the metaphors of science popping up in architecture—accidently uses a systems metaphor in the concluding sentence in his chapter on order: "If architecture does not create 'order'" he says, "there would be no need to have architecture at all…but if architecture is in the business of producing 'order', it is involved in something far bigger than it can possibly handle, the process by which experience is filtered, transformed and fed back to use in reduced form, all in the name of 'culture'." p 249.

16 Others doing this include Donna Haraway, "Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s," Socialist Review 80 (1985): 65-108. In Wolfe's first chapter is about the similarities in the way Jacques Derrida and Niklas Luhmann—two authors architects have been excited to conflate—confront the question of difference; the former to challenge the logocentric philosophical tradition and the latter through the problem that systems seek autopoiesis. In posthumanism, these are important because they "refuse to locate meaning in the realm of the human or biological."

17 See: Peg Rawes, Relational Architectural Ecologies: Architecture, Nature and Subjectivity, (New York: Routledge, 2013). See also: Ariane Lourie Harrison. *Architectural Theories of the Environment*. (New York: Taylor & Francis Group, 2013). This book actually contains the chapter on architecture from Cary Wolfe's book.

18 F.F. Varela, H. R. Maturana, R. Uribe, "Autopoiesis: The Organization of Living Systems, its Characterization and a Model," *Biosystems 5* (1974): 187-196. See also: Maturana, Humberto R, and Francisco J Varela. *The tree of knowledge: the biological roots of human understanding*. (Boston; Shambhala, 1992). See also: Wolfe, Cary, "In Search of Post-Humanist Theory: The Second-Order Cybernetics of Maturana and Varela," Cultural Critique 30 (1995): 33-70.

19 For a clear description of how Luhmann incorporates Autopoiesis, or what is called the 'Autopoiesis turn' in sociology see "Preface" in Niklas Luhmann. *Introduction to Systems Theory.* Polity Press, 2011.

20 Schumacher compares architecture to other historically produced subsystems discussed by Luhmann: "Luhmann discovers a series of important processes that determine these different systems within the era of modernity. The emerging market-orientation of the economy, the liberalization of the economy, is the pertinent way for the economy to become an autopoietic system. The political system has been evolving and succeeding through democratization, and only through democratization does it become a truly autopoietic, self-referentially closed system. The legal system found its autonomy and forward drive through positivism rather than natural law or God-given legal discourse. Art discovered its self-programming in romanticism. All of these mechanisms mean that these systems become autonomous and adaptive to each other. They become versatile, innovative, progressive, and ever-evolving. All these processes are established some-where between 1800 and 1900. My thesis here is that the concept of space, or the spatialization of architecture, is the equivalent of the democratization of the political system, the liberalization of the economy, etc." Of course, 'spatialization' or 'the concept of space' is not exclusive to architecture, in fact 'Autopoiesis' as understood by the biologists Varela and Maturana is both material and spatial. One could even ask, why, according to Schumacher, if space is the historically produced condition that allows for architecture's autonomy then why would 'second order systems' be an appropriate metaphor to conceptualize architecture, given that these conceptual models rely on terms, such as emergence and self-organization, which result in shifting questions from space to time? See: Patrick Schumacher, "Parametricism and the Autopoiesis of Architecture," *Log* 21 (March 2011), pp.63-79

21 Antoine Picon, "When Parametricism Tries to Reconnect with Vitruvius." *Log* 23 (2011): 53-57. See also: Eric Owen Moss, "Parametricism and Pied Piperism: Responding to Patrick Schumacher," *Log* 21, (2011), pp.81-87.

22 For a clear description of Eisenman's use of "deep structure see: Peggy Deamer. "Structuring Surfaces: The Legacy of the Whites." 94

23 Hays, K. Michael. "Critical Architecture: Between Culture and Form" *Perspecta,* Vol. 21, (1984): 14-29

24 This built upon Diana Agrest and Mario Gandelsonas's previous work on "the structure of the exchange between architecture and ideology, of architecture as ideology": "Design versus Non-Design," paper presented 1974; published in *Oppositions 6* (Fall 1976) found in *Architecture Theory since 1968. (Cambridge,* Mass: MIT, 1998), 198.

25 This ambition is described by Jeffrey Kipnis in "Is Resistance Futile?," *Log, no.5* (Spring/Summer 2005): 105-109.

26 Althusser uses a systems model to describe the way parts of the superstructure maintain their relative autonomy from the base in a structured but decentered totality. See: Althusser, L. and Balibar, E. *Reading Capital,* trans. Ben Brewster (London: New Left books, 1970) 58.

27 C. A. Doxiadis, Ekistics: An Introduction to the Science of Human Settlements (New York: Oxford University Press).

28 "Delos Declaration," and "The Delos Symposium," in Ekistics 16 (October 1963).

29 Constant was a member of the COBRA, and Guy Debord originally suggested the name of the city "New Babylon." After 1960, Constant and Debord would no longer work together. Constant would continue to use some idea of "cybernetics" in this project and would work on it for another ten years. During the 1960s Guy Debord was against the use of Cybernetics. See: Guy Debord, "L* Avant-garde de la présence," Internationale Situationniste 8 (January 1963): 20. For an interesting history of Debord arguing with GRAV about the possibilities of cybernetics to critique the spectacle see: Lily Woodruff. "The Groupe de Recherche d'Art Visuel against the Technocrats" Art Journal, Vol. 73, No. 3 (Fall 2014), pp. 18-37. For a description of the New Babylon Project see: Mark Wigley, Constant's New Babylon: a Hyper-Architecture of Desire (Rotterdam, 1998). Hilde Heynen, 'New Babylon: the Antinomies of Utopia', in Assemblage, 29, April 1996, 25-39.

30 Kenneth Frampton in describing this event doesn't attribute this change to systems thinking but conception of community (Gemeinschaft). Kenneth Frampton, *Modern Architecture: a Critical History* (London: Thames and Hudson, 1985), 269-279. See also: Le Corbusier, La Charte d'Athènes (1942), trans. The Athens Charter (New York, 1973).

31 Contradictions in connecting these two models have been pointed out by Kenneth Frampton, and Allan Colquhoun, for the simultaneous interest in recovering "the lost 'wholeness' of craft-based communities and cultures" and at the same time looking to the future with "a capitalist world of open structures within which democracy, individualism, commodification, and an ethos of consumption." Quote from Colquhoun, Modern Architecture, 234.

32 Hans Ulrich Obrist, *Yona Friedman: The Conversation Series* (Köln: Verlag der Buchhandlung Walther König, 2007) Stanley Mathews, *From Agit Prop to Free Space: The Architecture of Cedric Price* (London: Black Dog Publishing, 2007) Yona Friedman, *Yona Friedman / Pro Domo* (NY: Actar, 2006) Peter Lang and William Menking, *Superstudio: Life without Objects* (Milan: Skira, 2003); Simon Sadler, *Archigram: Architecture without Architecture* (Cambridge: The MIT Press, 2005), pp.2-10; 192-8 Mark Wigley, *Constant's New Babylon* (Rotterdam: 010 Uitgeverij, 1999);

33 The first is for clearly defined objectives and is understood as the typical architectural process from schematic design to construction documents to construction administration. In the second, he cites Ashby's introduction to Cybernetics and looks at the ways linear feedback (a series of designs are created and tested against performance criteria then measure until one satisfies that

criteria). The third and final option, involves learned behavior and is important for "user-participatory systems", where the architect creates a process that receives its own comprehensive evaluation, revises and generates other solutions and sorts and records those solutions. James Boyce, "What is Systems Approach?" in *Rethinking Technology: A Reader In Architectural Theory,* Eds. William Braham and Johnathan Hale, (New York: Routledge, 2007). 181-189.

34 Often *Agrupacion Espacio* has been written about as a CIAM "franchise" located in Peru who devotedly read Walter Gropius and Siegfried Giedion. Instead, as Sharif S. Kahatt has shown, *Agrupacion Espacio*, was reading Mario Quesada's book on modern architecture, *Espace en el Tiempo,* and the group was publicly outspoken against large state infrastructure projects based on Roosevelt's Tennessee Valley Authority instituted by Manuel Prado. See: Sharif Kahatt, "Agrupacion Espacio and CIAM Peru Group" in *Third World Modernism: Architecture, Development, and Identity*, Ed., Duanfang Lu, (Routledge: New York, 2011). For a summary of La Carta de Machu Pichu See: Silvia Sterental, "The Charter of Machu Pichu, Testimony to the advocacy and pursuit of Enlightened Principles of Planning and Design in Profession, Education and Practice," in The Fifth Column (winter, 1982); 16-17. According to Kahatt, this document was signed by Oscar Niemeyer, Bruno Zevi, Kenzo Tange, Santiago Agurto, Luis Miro Quesada, Fernando Belaunde, Jose Luis Sert, Buckminster Fuller, Paul Rudolf, and Gordon Bunshaft. Sarrif Kahatt also says that "La Carta De Machu Picchu" was presented at the Congress of the UIA in December 1977 in Cuzco. I haven't been able to find any record of this event; it is my belief that the charter was written in Cuzco and intended for the 13th world congress of the UIA in December 1978 in Mexico City, where all the signers of the document were present.

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